THE

Young Ladies and Gentlemen's

AUXILIARY,

IN

TAKING HEIGHTS AND DISTANCES,

CONTAINING THE

Use of the Small Pocket Case

OF

MATHEMATICAL INSTRUMENTS,

ILLUSTRATED BY

Practical Geometry,

THE

Knowledge of which is essential for the Student in Geography and Astronomy, as well as in Mensuration, Perspective and Architecture.

PART I.

SECOND EDITION.

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CONTENTS.

The Pupil is particularly requested to make the following corrections:

Page 12. For *by* elliptical, read *but* elliptical.
21. For 90 equal parts, read 9 equal parts.
33. For figure 73, read figure 76.
36. For figure 74, read figure 77.

PREFACE

TO THE FIRST EDITION.

THE present age has been remarkable for its attempts to facilitate the progress of youth. The elevated genius of Mrs. Barbauld has condescended to assist the infant mind in the acquirement of rational ideas:—Dr. Aikin has converted the thoughtless school-boy into an admirer of the works of nature, and a more general diffusion of knowledge has been happily effected by a variety of successful attempts to smooth the rugged paths of literature. A happy union of the useful and agreeable seldom fails to amuse and interest us; and though industry meets with no difficulties which are insurmountable, yet the rapidity of her progress must depend on the nature and number of the obstacles she has to encounter. She scales the mountain's top, or penetrates into the bowels of the earth—encompasses sea and land, or measures the arc of heaven—extends her calculations from world to world, and from one system to another, with more or less fatigue in proportion to the advantages she enjoys. There is an inactivity in the human mind analogous to the inertness of matter; every action must be produced by the impulse of some motive, and the art of the teacher principally

consists in being able to present such motives to the mind, as may produce the desired effects.

The mathematics are generally supposed to abound with uninteresting and tedious theories, not reducible to practice without long application and great fatigue.—But as the traveller, whose sole object is recreation, no sooner arrives at the gate of a building famed for being the repository of many curious productions of art and nature, than he is anxious to obtain admission; in like manner the human mind, become intimately acquainted with the introductory parts of science, feels an impulse to explore its less obvious magnificence and beauty.

The system of education, at this time generally adopted, expands the mind and enlarges its sphere of action. The broad basis of general information is by some regarded as dangerous, lest it should hinder the attainment of that degree of perfection, in any particular science, which a more limited application might produce.—By general knowledge a man becomes a more extensively useful member of society; and whenever genius finds opportunity for any particular application, the favorite passion is pursued with an ardor not less fervent, and probably affords pleasures not less delicious than his, who never steps beyond the periphery of a circle of a given radius, or who never thinks but according to the standard of some classical authority.

Young people, moreover, are often placed in situations adverse to their natural genius, which excite disgust when

they arrive at years of maturity; a contracted education unfits them for any other pursuit whereas a more liberal plan of instruction would enable them to profit by any change of circumstances, and extend the sphere of their utility.

The universal attention that is paid to Geography at this time; and the elements, at least, of Astronomy being considered as essential in any liberal plan of female education, led to a suggestion, that a familiar explanation of the use of the smaller cases of instruments, with an account of some easy methods of taking heights and distances, might perhaps contribute to the more ready diffusion of knowledge on such subjects.

If this little tract should contribute to furnish young persons with a rational amusement, repel an antipathy to the mathematics, and excite a desire of further investigation of a subject which instructs us to explain the various phænomena of the heavenly host, and a variety of authors will be sought for with avidity, and afford ample satisfaction.

NORWICH, 1800.

PREFACE

TO THE SECOND EDITION.

EVERY parent as well as every teacher is aware that information is more effectually conveyed to the minds of young persons by familiar conversation than by elaborate writings on any subject.

The success of the tutor, in his mode of exciting attention and interest in his pupils, depends on his varying the language of communication according to the quickness of comprehension which each pupil manifests—but the occasional mode of arguing, the similes, &c. to convey ideas most successfully, the interrogatory process to develope the hidden fund of juvenile knowledge already acquired, would appear ungracefully in print, because the reader cannot be minutely informed of the numerous varying discriminations requisite between cases of real ignorance and of diffident reserve.

Ask the scholar whether what has been said be well understood—the answer will probably be an affirmative. Every teacher knows that yes *is a spontaneous effect of a desire not to appear* inattentive, *and that more interrogation and more circumlocution are necessary to ascertain the degree of information actually acquired, but it is impossible to lay before the public the inquisitorial processes in the court of tuition.*

Series of questions may be judiciously arranged and usefully employed, many remarks and questions which the tutor, acting according to circumstances, cannot premeditate, will however be found necessary.

The strength of memory which some children possess will enable them to repeat verbatim the language of the author they have studied, it may therefore be expedient to vary the language of the questions and to accept answers in the youths' own phraseology in order to develope the latent workings of intellect.

Grammar is frequently learned by rote—Geography is learned by rote—History is learned by rote, but it is obvious to any one who attends to the consequences, that the words of the book adopted are repeated with no more exercise of the energies of the mind than a parrot is competent to display, provided the lessons were so short as to be incessantly repeated.

Geography and the use of the Globes are almost universally taught, but unless a proper foundation be laid—unless the geometrical parts of the science be understood—young ladies and young gentlemen will speak of parallels of latitude and meridian lines without any precise idea annexed to either of them.

The following gradation of instruction is intended not only to facilitate an acquaintance with Practical Geometry, but to introduce to the minds of young persons the knowledge of several things requisite to be understood in an early stage of their intellectual improvement.

PREFACE.

The former edition contained the use of the Sector, Logarithms, &c. but as this first volume comprises what is most important for beginners in Mensuration, Geography, and the Drawing Maps of the easiest construction—the second volume will contain the latter part of the first edition, with additions relative to Practical Astronomy.

As the knowledge of the derivation of terms gives correct ideas of their meaning, it is an effectual method of impressing them on the memory.

The most obvious etymology is adopted in the Auxiliary, and the same method will be observed in all the future publications relative to the sciences. When the Latin and Greek terms are nearly similar both are inserted; where the derivation can be easily traced to only one source, that alone is noticed.

A knowledge of the Greek Alphabet is a necessary acquisition to those who wish to become familiar with the Cælestial Globe, as the Stars are designated by the Greek letters to express their different magnitudes—thus, α, the first letter in the Greek Alphabet, is assigned to the largest star in each constellation—β, the second letter, to the next in size, &c. and when the number of stars exceeds the number of letters, the Italic letters are introduced. A Greek Alphabet is therefore prefixed to this small publication. Young persons in general will learn the Greek Alphabet as an amusement, and an hour's application will render them familiar with the characters.

NORWICH, 1814.

GREEK ALPHABET.

There are Twenty-four Letters in Greek.

Α, α,	Alpha,	a.
Β, β, ϐ,	Beta,	b.
Γ, γ, ʃ,	Gamma,	g.
Δ, δ,	Delta,	d.
Ε, ε,	Epsilon,	ĕ.
Ζ, ζ,	Zeta,	z.
Η, η,	Eta,	ē.
Θ, θ, ϑ,	Theta,	th.
Ι, ι,	Iota,	ī.
Κ, κ,	Kappa,	k.
Λ, λ,	Lambda,	l.
Μ, μ,	Mu,	m.
Ν, ν,	Nu,	n.
Ξ, ξ,	Xi,	x.
Ο, ο,	Omicron,	ŏ.
Π, π, ϖ,	Pi,	p.
Ρ, ρ,	Rho,	r.
Σ, σ, final σ, ς,	Sigma,	s.
Τ, τ, ꚍ,	Tau,	t.
Υ, υ,	Upsilon,	u.
Φ, φ,	Phi,	ph.
Χ, χ,	Chi,	ch.
Ψ, ψ,	Psi,	ps.
Ω, ω,	Omega,	ō.

NUMERALS.

Greek.	*Latin.*	*English.*
εἷς, ...	unus, ...	one.
δύο, ...	duo, ...	two.
τρεῖς, ...	tres, ...	three.
τέσσαρες, ...	quatuor, ...	four.
πέντε, ...	quinque, ...	five.
ἕξ, ...	sex, ...	six.
ἑπτὰ, ...	septem, ...	seven.
ὀκτὼ, ...	octo, ...	eight.
ἐννέα, ...	novem, ...	nine.
δέκα, ...	decem, ...	ten.
ἕνδεκα, ...	undecim, ...	eleven.
δώδεκα, ...	duodecim, ...	twelve.
τριακαίδεκα, ...	tredecim, ...	thirteen.
τεσσερακαίδεκα,	quatuordecim, ...	fourteen.
πεντεκαίδεκα, ...	quindecim, ...	fifteen.
ἑκκαίδεκα, ...	sexdecim, ...	sixteen.
ἑπτακαίδεκα, ...	septemdecim, ...	seventeen.
ὀκτωκαίδεκα, ...	octodecim, ...	eighteen.
ἐννεακαιδεκα, ...	novemdecim, ...	nineteen.
εἴκοσι, ...	viginti, ...	twenty.
εἴκοσι εἷς, ...	unus et viginti, ..	twenty-one

τριάκοντα, τεσσαράκοντα, πεντήκοντα, ἑξήκοντα, ἑβδομήκοντα, ὀγδοήκοντα, ἐννενήκοντα, ἑκατὸν.

Auxiliary, &c.

MATHEMATICAL* INSTRUMENTS.

A SMALL Case of Instruments contains a pair of compasses, one of whose points may be taken off and a drawing pen for ink or a crayon case for a lead pencil substituted in its place.

A semicircular or parallelogram protractor, a black lead pencil, a scale of $4\frac{1}{2}$ or 6 inches, according to the size of the case, are also included.

The protractor may be obtained separately when the case has not been furnished with it.

* Μαθημα Science. vid. Protractor and Plain Scale.

SECTION I.

Geometrical Definitions, with Remarks.*

A POINT is the minutest expressible part of a line, and may be conceived more minute than can be described by a pencil or pen.—*Fig.* 1.

* Γη the earth and μετρον measure.

A LINE—consists of a number of closely contiguous points.—*Fig.* 2.

A STRAIGHT OR RIGHT LINE—lies even between its extreme points; and only one right line can be drawn between any two points.

A CURVE LINE—deviates higher or lower between its extreme points.—*Fig.* 3.

A SERPENTINE LINE; a continuation of alternate curves.—*Fig.* 4.

PARALLEL LINES, whether straight or curved, are equally distant from each other in every part, and consequently can never meet.—*Fig.* 5.

Workmen suspend freely a *plumb* * or *plummet* by a string, which is called a *plumb line;* when it ceases to vibrate, it settles in a right line, inclining neither to the right nor the left side;—the line is then called perpendicular and hangs in a direction towards the centre of the earth.—*Fig.* 6.

* *Plumbum*, *lead*—the metal generally used for the weight. The plumb line is commonly fastened to the top of a board grooved to an open space, in the middle of which the weight hangs when the line is perpendicular.

The joiner's square is sometimes furnished with a line and weight, as in the former instrument.

CIRCLE.—If with any opening of the compasses one point be fixed on paper, &c. whilst the other describes a line around it in every part equally distant from the fixed point, that curved line is called the

* *circumference* or the † *periphery;* the space contained within the circumference is called the *circle*, and the fixed point the *centre* of the circle.—*Fig*. 7.

* *Circum*, around, *fero*, to bear. † Περι, around, φερω, to bear.

Diameter.‡—A line drawn from one point of the circumference of a circle through its centre to the opposite point, dividing the circle into two equal parts.—*Fig*. 8.

‡ δια through, and μετρον measure.

Radius.§—A line from the centre of a circle to the circumference—consequently the radius is half the diameter.—*Fig*. 9.

The plural of radius is *radii*.

§ Ραβδος. *Radius*, a ray of light, or spoke of a wheel, i. e. a right line from the centre.

Chord.‖—A line passing from one part of the circumference of a circle to another, but not passing through the centre.—*Fig*. 10.

‖ Χορδη, chorda, a string of a bow.

Arc.¶—Any part of the circumference of a circle.

¶ *Arcus*, a bow.

SEGMENT.*—The space contained between the the chord and the arc of a circle.

* *Seco*, to cut off.

Every circle, whatever its diameter, is universally considered as divisible into 360 parts, called degrees, and marked thus—360°.

Each degree contains 60 minutes, marked thus, ′—each minute contains 60 seconds, marked thus.″ The divisions are carried farther in Astronomical calculations, 60‴ thirds, one second, &c.

360 is a preferable number, because it may be divided into halves, quarters, and half-quarters—180°, 90°, 45°.

Let a circle be described and the diameter W E be drawn—open the compasses and find the point N in the circumference, at an equal distance from W and E—then draw a right line from that point, passing through the centre to the opposite point S.

You will then have two diameters, and the circle will be divided into four parts, containing 90° each; let the quarters of the circle be in like manner divided and two more diameters drawn—the number of radii will then be 8;—draw lines from each point to the third beyond it, and either darken one half of each point with Indian ink or apply different colours to the halves of each.—*Fig.* 11.

Let each space between the points be divided as before and there will be 16—divide again and there will be 32 points.—*Fig.* 12.

Figure 12 is a representation of a compass card used by mariners and surveyors, and frequently placed between the feet of the claw-footed stands of the terrestrial and celestial globes;—a magnetic needle, turning freely on a point, naturally places itself in the direction North and South—whence it is easy to determine the bearings, or on what point of the compass each of the surrounding places lies.

Because the Sun rises in the East, passes to the South of us, and sets in the West—hold the figure so that E may be towards the place of the Sun's appearance in the morning, and E will indicate the East, W the West, N the North, and S the South, both with respect to the earth and the heavens.

CARDINAL* POINTS.—The four points, EAST, WEST, NORTH, SOUTH.

RHUMBS.—The spaces between the four principal points, are subdivided into 8 points, which are called *Rhumbs*, so that the compass contains 32 points, each rhumb containing $11\frac{1}{4}$ degrees. These are described on the compass card, and also on the wooden horizon belonging to the globes. From the North towards the East these points are named

* *Cardinalis*, principal.

North and by East—North North-east—North-east by North—NORTH-EAST—North-east and by East—East North-east—East and by North, East, &c.

In the same manner the points are described from the East towards the South.

CONCENTRIC CIRCLES.—Two or more circles having the same centre.—*Fig.* 13.

Let two concentric circles be drawn, and draw two diameters so as to divide the circles into four quarters—divide the upper semicircle into 18 divisions, calling each division 10°, numbering them from 0 to 180;—if the half of each division be marked off, each space will represent 5°—and if the circle be sufficiently large, each single degree may be described with a fine pen.—*Fig.* 14.

SECTION II.

The following Definitions relative to Angles will now be easily understood.

AN ANGLE is the space contained between two right lines, drawn gradually nearer to each other till they met in a point, as A C B.—*Fig.* 15.

ANGULAR POINT.—The point where the two lines meet; in describing the angle we read A C B, placing C, the letter at the point, in the middle.

A Right Angle is formed when the space between the two lines is equal to 90°, i. e. a quarter of a circle.—*Fig*. 16.

In a right angle the lines forming the angle are perpendicular to each other.

Not more than four right angles can be described about the same point, because each right angle is one quarter of a circle.

Acute* Angle.—An angle containing fewer than 90°.—*Fig*. 17.

Obtuse † Angle.—An angle containing more than 90°.—*Fig*. 18.

The complement of an angle is what it wants of 90°.

The supplement of an angle is what it wants of 180°.

* *Acutus*, sharp.

† *Obtusus*, not pointed, i. e. less pointed than a Right Angle.

The Measure of an Angle Described.

Lay a thread from the centre C, fig. 14, to 30°, in the semicircle, and the thread line will form with the line C D an acute angle of 30°, i. e. B C D. 30°.

Apply a thread from centre C, fig. 14, to 120°, and the thread line will form an obtuse angle with the line C D.

SECTION III.

Of Erecting Perpendiculars, Dividing Lines, &c. with the Compasses.

*To *Bisect any given Line, as A B, into Two Equal Parts.*—Fig. 19.

With an opening of the compasses to more than half the given line—place one foot on B, one extremity of the given line, and describe an arc—then on A describe another arc, † intersecting the former in two points, and through the intersections draw the line C D.

* *Bis*, in twain. *Seco*, to cut. † *Inter*, between.

To Erect a Perpendicular from a given Point A in the Line A B.—Fig. 20.

Describe a circle of any radius, so that the point B may be in the circumference—from D the other points in A B cut by the circle draw a diameter, and from the termination of the diameter draw the line to E B.

To Erect or Let Fall a Perpendicular on any Point in a given Right Line.—Fig. 21.

Let C be the given point in the line A B—at equal distances from C mark D and E, and with any opening of the compasses greater than C E—place

one foot on E and describe a small arc as F—place the same foot on D and intersect the arc F by the arc G—then from the point of intersection draw a line to C, which will be the perpendicular required.

To Erect a Perpendicular on the Point B in the Line A B.—Fig. 22.

With any opening of the compasses set off B a on A B—fix one foot on a as a centre and describe the arc C B—with the same radius from B intersect the arc C B in d. On d as a centre describe F B—set off two extents from B in B F, and from the second draw a right line to B.

To Erect a Perpendicular on the Point B in A B.—Fig. 23.

With any opening place one foot of the compasses on B and describe an arc as F a—with one foot on F intersect the arc at C—on C describe the arc d f—on f describe C b, and draw a line through the point of intersection to the angular point.

To Draw a Line Parallel to a Line given.—Fig. 24.

With the compasses opened to the distance of the proposed parallel, taking points in the given line as centres, describe two arcs and draw the new line so as to touch these arcs without intersecting them.

To Divide an Angle into Two Equal Parts.—Fig. 25.

On the angular point as a centre describe an arc as a b—then on a and b, with the same radius, describe arcs intersecting each other, and draw a line from the angular point to the point of intersection.

To Divide a Line A B into any number of Equal Parts. Fig. 26.

Draw B C any angle and A D parallel to B C—lay off on B C and A D, the number of equal parts, for instance *five*, into which A B is to be divided, and join the opposite points by straight lines passing through A B.

To Describe a Helix or Spiral Line† A B.*—Fig. 27.

Draw A B and divide half of it into as many parts as there are to be revolutions of the proposed spiral, for instance *four*, thus, c d e f, then divide e f in g—and on g, as a centre, describe the semicircles above the line—and on f, as a centre, describe the semicircles below the line.

* ελιξ, a screw. † σπειρα, a line like a screw.

To Describe an Oval‡ on a given Line A B.—Fig. 28.

Divide A B into three equal parts—on C and D, as centres, describe circles intersecting each other, and with the extent A D on the points of intersection as centres describe the arc above and the arc below to complete the figure.

‡ *Ovum*, an egg. The resemblance consists in one diameter being shorter than the other.

To Describe an Oval from Three Circles.—Fig. 29.

Draw A B and divide it into four equal parts—on the three points D C E describe three circles—draw a diameter, F G to the middle circle at right angles with A B. On G, with an extent from G to the remotest part of the peripheries of the outer circles, describe the arc H I, and with the same extent on F describe the arc K L.

To Describe an Oval, the Short Diameter being three-fourths of the Long Diameter.—Fig. 30.

Draw A B and C D at right angles, and divide the short diameter into four equal parts. With an opening of the compasses equal to three-fourths of the short diameter make the points b and d centres in describing the arcs e C f and a D c—and with an opening equal to half the long diameter make the point P the centre of two arcs also, and the figure will be completed.

To Delineate a Circle with a Thread and Pencil. Fig. 31.

Stick a pin upright—take a thread and tie its ends together to form a loop, the length of the proposed radius. Let one end of the loop be around the pin and the other extended by the insertion of a black lead pencil—move the pencil round the pin as far distant as the loop will permit—the place of the pin

will be the centre, and the line described by the pencil will be the circumference or periphery of the circle.

An Ellipsis is a regular oval, possessing properties not found in the ovals above-mentioned.

Instruments as the Elliptical Compasses, the Geometric Pen, &c. are employed in drawing Ellipses, but as they are not likely to be in the hands of those for whose use this part of the Auxiliary is intended, it may be sufficient to notice one method of delineation.

To Delineate an Ellipse, having the Long and Short Diameter given.*

Draw the two diameters A B and C D—with an extent equal to half the long diameter, place one foot of the compasses at either end of the short diameter and intersect the long diameter at F f, which points of intersection will be the *two foci.*†

Erect a pin at each *focus* and form a loop around them equal in length to A B—then by the insertion of a pencil, as in the delineation of a circle, describe the Periphery of the Ellipse.

The Planets do not move in Circular by Elliptical Orbits—the Sun being in one of the *Foci.*

* ελλειπω, to be deficient—one diameter being shorter than the other

† φωνα, to burn.

SECTION IV.

Of Inscribing Figures in Circles.

A figure described by three equal sides is called a TRIGON. Four equal sides at right angles constitute a SQUARE.

To Inscribe an Equilateral TRIANGLE† or TRIGON‡ in a Circle.*—Fig. 32.

Draw the radius A C—with the extent of radius set one foot on A and intersect the circumference on each side, as B and D—draw the line B D, which will be the extent of one side of the proposed triangle

* *Equus*, equal. *Latus*, a side.

† *Tres*, three. *Angulus*, an angle.

‡ Τρεισ, three. γωνια, an angle.

To Inscribe a SQUARE in a Circle.—Fig. 33.

Draw the diameters A B and C D at right angles, and draw the chords C A, A D, B D, and B C.

POLYGONS.§

§ Πολυς, many. γωνια, an angle.

All figures having more than four sides are denominated Polygons—if the sides of the figure are

equal it is called a Regular Polygon—if unequal, an Irregular Polygon.

To Inscribe a PENTAGON* *in a Circle.*—Fig. 34.

Draw two diameters at right angles—divide the radius C D into two equal parts, on E with the extent E A describe the arc A F—and on A describe F G—then draw the line G A, which will be the measure of one side of a pentagon.

* Πεντε, five. γωνια, an angle.

To Inscribe a HEXAGON† *in a Circle.*—Fig. 35.

Set off the radius of the circle six times on the circumference and draw the chords to the six arcs.

† Εξ, six. γωνια, an angle.

To Inscribe a Heptagon‡ *in a Circle.*—Fig. 36.

Draw the radius A C—with that extent set one foot of the compasses on A and describe the arc b C b—draw the right line b b, and half b b set off seven times on the circumference will mark the limits of the sides of the Heptagon very nearly.

‡ Επτα, *Septem*, seven. γωνια, an angle.

To Inscribe an OCTAGON§ *in a Circle.*—Fig. 37.

Half an arc of the side of the square will be the arc of one side of the octagon.

§ Οκτω, *Octo*, eight. γωνια, an angle.

To Inscribe an Enneagon or Nonagon† in a Circle.*
Fig. 38.

Set off the extent of one third of the arc of a side of the triangle nine times on the circumference.

Or with more geometrical accuracy thus—

Draw a radius A B—with the extent of radius and one foot on B describe the arc C A D—draw C E D at the extremities of the arc, and extend it so as to make E D F equal to radius—upon the point F describe the arc E G and draw the line A G—on E describe F G, to which from D draw D H, the side of the polygon proposed—*nearly*.

* εννεα. † *Novem*, nine. γωνια, an angle.

To Inscribe a DECAGON ‡ *in a Circle.*—Fig. 39.

Half the arc of one side of a pentagon will be the arc of one side of a decagon.

‡ Δεκα, *Decem*, ten. γωνια, an angle.

To Inscribe an Endecagon § *in a Circle.*—Fig. 40.

Draw the radius A B, bisect it in C—with an opening of the compasses equal to half the radius, upon A and C as centres describe the arcs C D I and A D—with the distance I D upon I describe the arc D O and draw the line C O, which will be the extent

§ Ενδεκα, *Undecem*, eleven. γωνια, an angle.

of one side of an endecagon sufficiently exact for practice.

To Inscribe a Dodecagon in a Circle.*—Fig. 41.

Half the arc of one side of an hexagon will be the arc of one side of the dodecagon.

* Δωδεκα, *Duodecim*, twelve. γωνια, an angle.

To Inscribe a Polygon in a Circle.—Fig. 42.

Divide the diameter A B into equal parts, corresponding to the number of sides in the proposed Polygon.

Erect a perpendicular from the centre, and extend it to C, three-fourths of radius beyond the circumference;—draw the line C D through the second division of the diameter, and the chord D A will be the side of a heptagon, the polygon required in this instance.

To Inscribe Regular Figures in a Circle.—Fig. 43.

Draw the two diameters and with radius, on the extremities of each, describe arcs and number the divisions on the circumference from 30 to 360.

30 will be the side of a dodecagon—60 the side of a hexagon—90 the side of a square—120 the side of a trigon.

Draw a line from the centre through the intersections of two arcs and the chord A B will be the side of an octagon.

To Ascertain the Centre of a Circle.—Fig. 44.

Draw any chord A B—bisect it with a perpendicular equal to the extent of the circle—bisect the perpendicular, and each part will be a radius, and consequently the point where the two radii meet is the centre.

To Describe the Circumference of a Circle through three given Points, not in a Straight Line.—Fig. 45.

Draw two lines to connect the middle point with the others;—on the middle of those lines erect perpendiculars and extend them till they meet.—On the point of intersection with its distance from one of the given points describe the circle.

By this method the centre of a circle may be ascertained; or if only an arc be given, the centre may be found and the circumference of a circle completed—or a circle may be circumscribed about a given triangle.

The number of triangles into which a polygon may be divided and its number of sides are equal.

The angles of any polygon, regular or irregular, added together amount to twice as many right angles, excepting four, as the figure has sides.

Regular polygons may either be inscribed *in* or described *about* a circle.

SECTION V.

Of the Protractor.

The Protractor is usually of a semicircular form, graduated into 180° and is numbered both ways for the conveniency of laying down or measuring angles in any direction.

The plain edge is the diameter, and a fine mark, at the middle of it, is the centre of a circle.

The Protractor is sometimes in the form of a ruler, to which the divisions are transferred from the semicircle—the outline of two figures will serve to shew the correspondence between them.—*Fig*. 46.

To Lay Down an Angle B of 45°.—Fig. 47.

Draw the line A B, place the edge of the Protractor exactly upon it, and the central mark on the point B, then make a dot at 45° C, and a line drawn from C to B will describe the angle required.

To Measure an Angle.

Place the centre of the protractor on an angular point, and the plain edge exactly on the line A B, the number of degrees cut by the line C B will be the measure of an angle B 45°.

To Erect a Perpendicular to a given Line.

Let the angle laid down be 90°, and one line will be perpendicular to the other.

Polygons.

As every circle is supposed to be divided into 360°, that number divided by the number of sides in the polygon required, has for its quotient the number of angles at the centre; and if the angles at the centre be subtracted from 180°, the remainder will be the angle at the circumference.

A TABLE

Of Angles at the Centres and Circumferences of Regular Polygons.

Sides.	*Names.*	*Angles at the Centre.*	*Angles at the Circumference.*
3	Trigon	120°	60°
4	Square	90°	90
5	Pentagon	72	108
6	Hexagon	60	120
7	Heptagon	51, 25 $\frac{5}{7}$	128, 34 $\frac{2}{7}$
8	Octagon	45	135
9	Nonagon	40	140
10	Decagon	36	144
11	Endecagon	32, 43 $\frac{7}{11}$	147, 16 $\frac{4}{11}$
12	Dodecagon	30	150

To Inscribe in a Circle a Polygon of any number of Sides.

Apply the diameter of the protractor to the diameter of the circle, and let their centres coincide;—

mark the degree given for the angle at the centre of the proposed polygon and draw a radius, then a chord of an arc equal to the given angle will be one side of the polygon required.

The Plain Scale.

There are usually six or seven scales of different dimensions on the side called the *Plain Scale*.

Each scale is divided into equal spaces, which bear a certain proportion to an inch as one-third, one-fourth, &c. The number at the beginning of each scale, as 20, 25, 30, &c. indicates into how many parts an inch is divided.

A space equal to one division on the scale is marked with 10 subdivisions—the fifth, for the sake of distinction, is a longer stroke than the others.

If *one* in the scale be designed to represent one foot, yard, mile, league, &c. the compasses extended from 1 to 3 in the smaller divisions will express one and three-tenths—from 2 to the 5th subdivision will express two and five tenths, &c. which extent set off on a line will represent one and three tenths of a mile, yard, &c.

The size of the plan of any drawing will vary according to the scale employed.

If 1 be called 10, the subdivisions will be so many units—if 1 be reckoned 100, the subdivisions will be tens—if 1 be called a 1000, the subdivisions will be hundreds.

On the best scales the upper line is marked into 12 subdivisions, of which the 3d, 6th, and 9th, particularly the 6th, are longest.

To set off 530, or 53, or 5 and three tenths.

Place one foot of the compasses at 5 on the large divisions, and extend the other foot to 3 amongst the subdivisions.

To express 4 feet 8 inches with a scale whose upper line is divided into 12 parts.

Place one foot of the compasses on 4 amongst the large divisions and extend the other foot to 8 amongst the subdivisions—and mark off that extent on any proposed line.

THE LINE OF CHORDS.

The large divisions on the uppermost scale end sooner than the rest, to admit a *line* of chords, marked Cho or C and numbered to 90°.

The line of chords is used in preference to the protractor, for laying off or measuring angles.

To Construct a Line of Chords.—Fig. 48.

Divide the arc of one quarter of a circle into 90 equal parts, containing 10° each—draw the chord, and with one foot of the compasses on A as a centre, transfer the divisions of the arc A B to the chord A B—annex the corresponding figures to the right

line A B, and it will be a line of chords. A chord of 60° is equal to radius, i. e. A 60° is equal to A C.

To Lay Down an Angle of 25° at the Point A in the Line F A.—Fig. 49.

Set one foot of the compasses at C, the beginning of the line of chords, and extend the other to 60—then on A as a centre describe an arc F G—take the extent from C on the line of chords to 25°, and set it off on the arc F G—draw the line G A, and the angle F A G will equal 25°.

To Measure an Angle by the Line of Chords.

With a chord of 60° place one foot of the compasses on the angular point and describe an arc—then take the extent of the arc contained between the two lines forming the angle, and apply one foot to the begining of the line of chords on the scale, and the other will extend to the degree which will denominate the measure of the angle—thus the angle F A G given will be 25°.

Describe a Circle with Radius of 60° taken from the Line of Chords, and Divide 360 by the number of Sides in the proposed Figure.

90 on the line of Chords will give one side of a Square.
72 .... a Pentagon.
60 .... an Hexagon.

45 on the line of Chords will give one side of an Octagon
40 . . . . an Enneagon or Nonagon.
36 . . . . a Decagon.
30 . . . . a Dodecagon.

The Heptagon and the Endecagon not being divisible by their respective numbers, may be found by other methods.

If the line of chords on the scale be too large for the proposed circle, describe the line of chords on the diameter extended, and draw a line from the measured degree to the centre of the circle.

The Diagonal Scale.

On the other side of the scale is *a line of inches* according to its length, divided like rulers in general into inches and tenths of an inch.

Also a line of equal parts, which shews the foot to be divided into an 100 equal parts. The six-inch scales extend to 50, and thus 3 inches are 25 parts of the said foot.

The *scale diagonally divided* is used for the same purpose as the plain scales already described—but whilst the small divisions on the plain scales express the *tenths* of one of the large divisions, the diagonal scale is adapted to a greater degree of exactness; it serves to express the hundredth part of one of the large divisions, for which reason it is called a Centessimal* Scale.

* *Centum*, an hundred.

At one end of the scale is a part equal to one of the large divisions, divided at the top and the bottom into 10 parts, which, by diagonal lines drawn from the 10th below to the 9th above, subdivide the said 10 parts into a hundred less proportional parts, by which means not only the 10th of a number may be expressed but the 10th of that 10th.

Thus for 245.—The second large division expresses 200—the fourth diagonal expresses four tenths or 40, and the fifth parallel expresses 5.

There are two *diagonal subdivisions*, one at each end of the scale—the one is exactly half the length of the other.

The larger divisions are numbered 1, 2, 3, 4, &c. according to the length of the scale. The half-sized divisions are numbered at the bottom.

Ten parallel lines, from one end to the other, are numbered 2, 4, 6, 8, at the ends, and the diagonals are also numbered 2, 4, 6, 8 on the top, by which the lines are readily distinguished.

Set off 284.

Place one foot of the compasses where the unit 4 intersects the diagonal of the tens 8, and extend the other foot to the hundreds expressed by the large divisions—thus place one foot where the 4th parallel meets the 8th diagonal, and extend the other foot to 2 amongst the large divisions.

Set off 567.

Place one foot of the compasses where the 7th parallel meets the 6th diagonal, and extend the other foot to 5 amongst the large divisions.

Observe.—If the part diagonally divided be called 1, then the subdivisions are of the same description as those on the plain scales, i. e. tenths of one.

If the part diagonally divided be called 10, then the large divisions express tens, the number of the diagonal expresses the 10th parts of ten, and the number of the parallels shews the ten minute parts.

If the part diagonally divided be called 100, then the numbers on the large divisions express hundreds—the number in the diagonals expresses tens, and the number on the parallel notes units—thus, 284, 567, 632, to be set off on a given line.

GEOMETRICAL THEOREMS RELATIVE TO ANGLES.

Theorem 1.—Fig. 50.

A right line A B forms with another line C D two angles, the measures of which added together are equal to two right angles—thus, if A B D be 64°, A B C will be 116°, the number of degrees in the semicircle being 180°.

Theorem 2.—Fig. 51.

The opposite angles made by two right lines intersecting each other are equal, as a and b, c and d.

Theorem 3.—Fig. 52.

A right line intersecting two parallel lines makes the opposite angles at each intersection equal.

THEOREMS RELATIVE TO CIRCLES.

Theorem 1.—Fig. 53.

The angle at the centre of a circle is double the angle at the circumference when both of them stand on the same arc, i. e. A B C is double the angle A D C.

The measure of an angle at the *centre* is the arc contained between the lines forming the angle—but the angle at the *circumference* may be proved by measurement to be only *half* the arc at the centre.

Theorem 2.—Fig. 54.

An angle in a semicircle* is a right angle at the circumference.

The arc A D C which measures the angle A B C is a semicircle, half which is 90°.

* *Semis*, half.

Theorem 3.—Fig. 55.

An angle made in a segment greater than a semicircle is *acute*, as B A F.

Theorem 4.—Fig. 56.

An angle in a segment less than a semicircle is *obtuse*, as may be proved by measuring the angles.

SECTION VI.

Of Quadrangles or Quadrilateral† Figures.*

Tetragon ‡ is a term applicable to every figure having four angles.

* *Quatuor*, four. *Angulus*, an angle.

† *Quatuor*, four *Latus*, a side.

‡ Τετρα, four. γωνια, an angle.

Τετρα is for τεττερα, and τεττερα for τεσσερα.

To Describe a Square.—Fig. 57.

Draw the line A B, one side of the proposed square—at one end of the line erect a perpendicular with the protractor, or the line of chords, or any of the preceding directions.—Make the perpendicular equal to the side A B, and with the extent of A B on A and C describe arcs, and the point of intersection will determine the boundaries of the figure.

To Describe a Parallelogram.—Fig. 58.

A right line figure, which like a square contains four right angles, but whose opposite sides only are equal.

Draw A B one of the long sides—erect a perpendicular B C equal to one of the short sides, and with the extent of A B on C describe the arc at D, and with the extent of B C on A intersect it by another arc, and draw A D and C D to complete the figure.

To Describe a Rhombus.—Fig. 59.

A Rhombus is formed by four equal lines and contains four angles, two of which are acute and two obtuse.

Draw the side A B and lay down the angle at A. Suppose 36°—draw A C equal to A B, and with intersections as in describing the square draw B D and C D.

To Describe a Rhomboides.—Fig. 60.

A Rhomboides differs from a parallelogram as a rhombus differs from a square—draw one side and lay down the angle A—suppose 45°, and proceed as in the parallelogram to complete the figure.

To Describe a Trapezium.—Fig. 61.

A Trapezium is a figure bounded by four unequal sides and containing four unequal angles.

Take the given lines from the plain or the diagonal scale and connect them according to the given angles.

To Describe a Trapezoid.—Fig. 62.

A Trapezoid differs only from a trapezium by having two of its four sides parallel.

Irregular Polygons.—Fig. 63.

All unequal right-line figures under more than four sides are called irregular polygons.

The directions for describing the trapezoid and the irregular polygons are the same as given above for the trapezium.

Theorems Relative to Four-sided Figures.

Theorem 1.—Fig. 64.

The four inward angles of a quadrangle or quadilateral taken together are equal to four right angles.

Theorem 2.—Fig. 65.

Parallelograms on the same base and between the same parallels are equal, i. e. A B C D is equal to B E F C.

SECTION VII.

Of Right Lined Triangles.

A figure bounded by three right lines is called a Triangle.

A Right Angled Triangle is distinguished by one of its angles being an angle of 90°.—*Fig*. 66.

An Obtuse Angled Triangle has one obtuse angle.—*Fig*. 67.

An Acute Angled Triangle has its three angles acute.—*Fig*. 68.

An Equilateral Triangle has its three sides equal.—*Fig*. 69.

An Isosceles Triangle has only two sides equal.*—Fig. 70.

* Ισος, *equal.* Σκαλος, *a leg.*

A Scalene † *Triangle* has its three sides unequal.—*Fig.* 71.

† Σκαληνος, *oblique and unequal.*

In every triangle the longest side and the greatest angle are opposite to each other.

To Describe a Triangle.—Fig. 72.

Draw one side as A B of the extent required—on A, with the extent of another line A C, describe an arc at C—and with the extent of the third line B C intersect the arc at C—then draw lines to complete the figure.

Theorems Relative to Triangles.

Theorem 1.—Fig. 73.

In every triangle the sum of all the angles is equal to 180°, i. e. two right angles.

Therefore—If any two angles in a triangle be known, their sum taken from 180° gives the remaining angle.

If *one* angle be a *right angle*, the *other two* angles added together equal the other right angle.

If one angle in a triangle be a *right* or an *obtuse* angle, the other *two* angles are *acute*.

If in a right angled triangle *one* of the *acute* angles be known, subtract it from 90°, and the remainder is the other acute angle.

Theorem 2.—Fig. 74.

If one side of a right angled triangle be produced, the outward angle will be equal to the two inward opposite angles.

Observe.—In every right angled triangle the side opposite the greatest angle is called the Hypotenuse,* the upright side the perpendicular, and the other side the Base.†

* υπο, under. τεινω, to extend.

† Βαθος, the lowest place.

Theorem 3.—Fig. 75.

In a right angled triangle the square ‡ of the hypotenuse or longest side is equal to the square of the base and the square of the perpendicular added together.

‡ The square of a number is found by multiplying it by the same number, thus—3 multiplied by 3 is 9, the square of 3.

An inspection of the figure illustrates this property of the right angled triangle, the knowledge of

which is of great use in most branches of the Mathematics.*

* Pythagoras, a celebrated Grecian Philosopher, is recorded to have been the first who made this discovery.

" It is said, that he was so elated after making the discovery, that he made an offering of a hecatomb to the Gods; but the sacrifice was undoubtedly of small oxen, made with wax, as the philosopher was ever an enemy to shedding the blood of all animals. His System of the Universe, in which he placed the Sun in the centre, and all the Planets moving in elliptical orbits round it, was deemed chimerical and improbable, till the deep enquiries and the philosophy of the 16th century proved it by the most accurate calculations to be true and incontestable."—*Lempriere's Dict.*

SECTION VIII.

Trigonometrical Problems for Laying Down the Sides of Right Angled Triangles.

Problem 1.—Fig. 76.

The BASE and PERPENDICULAR given to find the HYPOTENUSE.

Given.	*Required.*
A B Base 20.	A C Hypotenuse.
B C Perpendicular 15.	

Draw a line and set off from a scale of equal parts A B 20—erect a perpendicular on the point B—open the compasses to 15 on the same scale as before—apply that extent to the perpendicular from the point B and intersect B C in C—then draw the line A C—

the extent of which applied to the scale will be 25, the length of A C, the hypotenuse.

Problem 2.—Fig. 73.

The Base and the Hypotenuse given to find the Perpendicular.

Given.	*Required.*
A B Base 30.	B C Perpendicular.
A C Hypotenuse 50.	

Draw the base and set off 30 from the scale of equal parts—erect a perpendicular at B—take from the same scale the length of the hypotenuse 50, and with one foot on A extend the other to intersect the perpendicular in C—from that point of intersection draw the line C A, by which the triangle will be completed—apply the extent of B C to the scale, and it will be 40, the perpendicular required.

If the Hypotenuse and Perpendicular were given, and the Base required, the operation would be the same, substituting Perpendicular instead of Base—thus,

Given.	*Required.*
B C Perpendicular.	A B Base.
A C Hypotenuse.	

In the above trigonometrical problems for determining the sides of right-angled plain triangles, two sides were given and only one side remained to be sought.

In those cases wherein the *perpendicular*, i. e. the height of the object, is not known, and the distance of the observer, viz. the *base* of the triangle, does not admit of the application of any measure, and no line can be extended from the top of the object to the place of the observer, in order to ascertain the *hypotenuse*; it is by this time obvious to the pupil that neither HEIGHT nor DISTANCE can be determined; for unless *two* of the lines could be previously known, the *third* cannot be determined by the foregoing rules.

The invention of optical, mathematical, and philosophical instruments, has abundantly contributed to increase the rational amusements of mankind; the principles on which they are constructed are not so uninteresting as they may at first appear; every theorem has its correspondent practical operation; every problem admits of a solution applicable to some of the purposes of life. The benefits resulting to society from such studies are innumerable.—Each individual amongst us is at least a practical geometrician, and the mind naturally acquires much more knowledge of the theory of geometry than is usually apprehended. Neither extraordinary labour, nor much time is requisite for gaining a competent knowledge of those scientific truths which are of use in the common concerns of life. And we may venture to assert, that an attention to mathematical rules is an

inexhaustible source of recreation, conduces to the promotion of our interest, and enables the mind most clearly to discern the excellent order in the system of the universe, seeing that "God has ordered all things in measure, number, and weight."

The ingenious contrivances of mankind to increase the faculty of vision, by means of telescopes; and with quadrants, theodolites,* &c. to ascertain the heights and distances of accessible or inaccessible objects, are to be numbered amongst the evidences, which prove that the power God has bestowed on man was appropriated to him for the investigation of truth, and the observance of the harmony of the celestial system.

* Θεομαι, to see. οδος, distance.

SECTION IX.

Quadrant, &c.

Amongst the variety of ingenious and useful inventions which have been adopted for taking the angle of observation, it will be sufficient for the illustration of the following problems if two only be mentioned.

The instruments called Quadrants are variously contrived, and furnished with different apparatus, according to the uses for which they are designed. Every quadrant is the fourth part of a circle, having

the arc divided into 90°, and subdivided more or less according to the size of the instrument—every 10th degree being drawn longer than the rest.

If the juvenile mechanic wishes to supply himself with a quadrant, let him take a smooth flat board, and having described upon it an exact quarter of a circle, and graduated the arc as in fig. 74, place a pin at the centre and from it suspend a thread and plummet—the heavier the plummet the more steadily it will hang, and the observation may be made more correct;—on the side B C let two thin plates of brass, with very small holes, exactly in a right line, be placed parallel to the side of the quadrant.

Another simple instrument is called a Quadrat, or Geometric Square—it consists of four rules joined together at right angles; at A a thread and plummet is suspended, and occasionally a moveable index attached; the sides B E and D E are divided into 50 or 100, and if the instrument be large, into 1000 equal parts—two sights are fixed on the side A D, similar to those above-mentioned.

The quadrant invented by Mr. Gunter, whose name it bears, has also a quadrat delineated upon it, and is not only useful in taking the angle of vision but serves for a variety of astronomical problems, which will be described in the second Vol.

Gunter's Quadrant being an instrument not liable to accident and of a moderate price, is most likely to be in the hands of young persons.

To Take an Angle of Altitude with the Quadrant.

Hold the quadrant in the direction B C, so that the top of the object may be viewed through both sights at the same time—and the plumb line will cut the arc of the quadrant in the number of degrees and parts of a degree equal to the angle of altitude, i. e. the arc of the quadrant will be equal to the angle A C T.

When the object is higher than the eye of the spectator, the angle taken is the angle of altitude—when the object is lower than the eye of the observer, it is called the angle of depression.

To take an Angle of Depression.

Apply the eye to the centre and observe the angle on the other side of the plumb line.

SECTION X.

Trigonometrical Problems for Ascertaining the Angles and Measuring the Sides or Legs of Right Angled Triangles.

PROBLEM 1.

The Base and Perpendicular, i. e. the two Legs of

a Right Angled Triangle given to find the Acute Angles and the Hypotenuse.

Given.	*Required.*
A B 45.	Angle A.
B C 80.	Angle C.
	A C.

From either the plain or diagonal scale, draw the base A B 45 and the perpendicular B C 80, and complete the construction of the triangle by drawing the hypotenuse A C.

Measure one of the acute angles with the arc of 60 from the line of chords, the other will be the complement of the first—and apply the extent A C to the same scale used for the base and perpendicular.

Answ.—Angle A 60° 30′.

Angle C 29° 30′. Hypotenuse 92 nearly.

Problem 2.

The Hypotenuse and one Leg of a Right Angled Triangle given to find the Angles and the other Leg.

Given.	*Required.*
Perpendicular B C 75.	Angle A.
Hypotenuse A C 130.	Angle C.
	Base A B.

Draw a line, on which the base line A B is to be set off.

On B erect the perpendicular B C 75, reckoned on a selected scale; take 130 from the same scale,

and on C as a centre, with a radius of 130, describe an arc intersecting the line drawn for the base at A—complete the triangle by drawing the line A C, then measure one of the acute angles and the base.

Answ.—Angle A 35° 15′. Angle C 54° 45′.
Base A B 106 and 2 tenths.

PROBLEM 3.

The Angles and one Leg of a Right Angled Triangle given to complete the figure, and find the other Leg and the Hypotenuse.

Given.	*Required.*
Angle A 65° 30′.	Perpendicular B C.
Base A B 400.	Hypotenuse A C.

Draw A B equal to 400 measured on a diagonal scale—erect a perpendicular at B—at the point A form an angle 65° 30′, and draw A C till it extends to the perpendicular.

The complement of angle A will be angle C—B C and A C applied to the same diagonal scale which was used for the base, will give

Perpendicular B C 877.
Hypotenuse A C 964½.

PROBLEM 4.

The Angles and Hypotenuse given to find the Legs of a Right Angled Triangle.

Given.	*Required.*
Angle A 51°.	Base A B.
Hypotenuse A C 474.	Perpendicular B C.

Draw the line A B of an indeterminate length; at A form an angle 51°—with the line A C, from a diagonal scale, make A C represent 474; let fall a perpendicular from C, meeting the base in the point B.

Angle C is known by its being the complement of angle A—let A B and B C be measured by the same diagonal scale used in setting off A C, and the answer will be

Base A B 298.

Perpendicular B C 368.

SECTION XI.

Oblique Angled Triangles.

PROBLEM 1.

Two Angles of an Oblique Angled Triangle, and the side opposite to one of the Angles given to find the other side.

Given.	*Required.*
Angle C 60°.	A C
Angle A 50°.	B C
A B 450.	

Add together the two given angles and subtract their sum from 180°—the remainder will be angle B.

Draw A B 450—lay down angle A 50° and angle B 70°—A C and B C meeting in a point complete the figure.

Answ.—A C 488 and 3 tenths. B C 398.

PROBLEM 2.

Two Sides of an Oblique Angled Triangle and an Angle opposite to one of them, given to find the other Angles and the third Side.

Given.	*Required.*
A B 525.	Angle A.
A C 475.	Angle C.
B 51°.	B. C.

Draw the line A B 525—at B make the angle 51°—take the extent of A C as a radius, and on A as a centre intersect B C in C—then draw A C to complete the figure.

Answ.—Angle A 69°$\frac{3}{4}$, i. e. 45′.
Angle C 59°$\frac{1}{4}$, i. e. 15′.
B C 573 and 6 tenths.

PROBLEM 3.

Two Sides and the Angle formed by them given to find the third side and the remaining Angles.

Given.	*Required.*
A C 352.	Angle A.
B C 266.	Angle B.
C 73°.	A B.

Draw A C and B C, making an angle 73° at C, and draw A B to complete the figure.

Apply the extent of A B to the scale—*Answ. 374.*

Measure one angle either A or B—add the angle found to the angle given, and the third angle being the supplement of the sum of the two angles, will be known by subtracting that sum from 180°.

Answers.—Angle A 42° 45′. Angle B 64° 15

A B 374.

SECTION XII.

Of Solids.

The square,* the rhombus,† the parallelogram,‡ the rhomboides,§ the triangle, &c. already noticed, relate only to the superficies or plane surfaces, bounded by the lines of the respective figures, and are therefore said to have only two dimensions—*length* and *breadth.*

* *Quadra,* Quatra, from quatuor.

† Ρεμβω, to deviate. The angles of the figure deviate from right angles.

The term *Rhumb,* page 5, is from the same origin Ρεμβω.

When a ship sails in any other direction than to one of the four cardinal points, her course is described by a *rhumb line.* If the course were continued in an oblique direction, it would not describe a circle, but a figure more resembling a spiral.

‡ Παραλληλος, mutual. γραμμη, a line.

§ Ρομβος, rhumb. ειδος, form.

Solids—are bodies which have three dimensions—*length*, *breadth*, and *thickness*.

A Cube * is a solid contained by six square sides.—*Fig*. 78.

* Κυβος, a die.

A Cuboides† or Parallelopipedon‡ is a solid having six quadrangular surfaces, every opposite pair equal and parallel.—*Fig*. 79.

† Κυβοσ, a cube. ειδος, form.

‡ παραλληλοι. ποδες, feet.

A Prism § is a solid whose ends are similar, equal, and parallel, and its sides parallelograms.—*Fig*. 80.

§ Πρισμα, from πριω, to cut with a saw.

A prism of solid glass in an instrument employed for separating the rays of solar || light.

|| *Sol*, the Sun.

If the young philosopher ¶ form a prism with three pieces of glass, and securing the ends with clay, wood or metal, fill the prism with water, he may be gratified by an exhibition of a series of beautiful colours and be prepared to admire the more splendid effects of a glass prism accurately ground and polished.

¶ φιλος, a lover. Σοφια, wisdom.

The term prism is, however, applied by geometricians to any figures whose ends are similar, parallel, and equal, and whose sides are parallelograms—thus the ends of prisms may resemble the triangle, the square, the pentagon, the hexagon, &c.

A PYRAMID * is a solid having any of the different figures for its base—triangular sides meeting in a point at the top.—*Fig.* 81.

* Πυρ, fire, because flame ascends to a point.

A CONE † is a solid having a circular base—the figure gradually decreasing towards the vertex or top, and ends in a point.—*Fig.* 82.

† Κωνος.

A CYLINDER ‡ is a solid having circular ends and being circular in its whole extent.—*Fig.* 83.

‡ Κυλινδω, to roll.

A SPHERE § or GLOBE is a solid whose surface is uniform, and therefore every part equally distant from a point within called the centre of the sphere.—*Fig.* 84.

§ *Sphera.*

A SEGMENT is a part cut off the top of any solid parallel to the base.—*Fig.* 85.

A FRUSTUM* is the part remaining after the segment is cut off.—*Fig.* 86.

* *Frustum*, a fragment.

A ZONE † is that part of a sphere which is between two parallels.—*Fig.* 87.

† Ζωνη, a belt.

The term *Zone* is particularly applied to *five* divisions of the earth—the spaces consisting of $23\frac{1}{2}$ degrees between the *Equator* ‡ on the Globe and the *Tropic* § of CANCER, and between the Equator and the Tropic of Capricorn might be called *two* Zones, but as they are contiguous to each other and comprise the whole of that space over some part of which the Sun in its daily apparent progress becomes perpendicular, it is usual to consider them as *one Zone*, denominated the Torrid. ||

‡ *Equus*, equal. The circle divides the globe into two equal parts, the Northern and Southern hemispheres.

§ Τρεπτω, to turn—because the Sun appears to turn or change its course back again when arrived at either of the circles denominated the Tropics, which are two small circles parallel to the Equator—the former passing through the beginning of the sign Cancer—the latter through the beginning of the sign Capricorn.

|| *Torreo*, to scorch.

The spaces between the parallel of the *Tropic of Cancer* and the *Arctic Circle*, and between the Tropic of Capricorn and the *Antarctic Circle*, are denominated the North and South *Temperate* Zones; and the spaces cut off by the parallel of the Arctic Circle and by the parallel of the Antarctic Circle are termed *Frigid Zones.*

Αρκτος, a bear.

Αντι, against or opposite Αρκτος.

Temperantia, moderate heat.

Ριγιος, *frigidus*, cold.

SECTION XIII.

Planimetry, or the Measurement of Plane Surfaces.*

Although this publication is not intended as a substitute for a treatise on mensuration, it may be useful to supply the pupil with the simple rules for the measurement of plane surfaces.

* *Planus*, plain. μετρεω, to measure.

Numerous opportunities offer for rendering the application of the rules a source of amusement—as the superficial content or area of a *sheet of paper*, a *table*, or *carpet*, *a side wall of a room*, *an entire room*, *a garden*, *&c.* may be ascertained by them.

To Measure a Quadrangular Figure whose opposite Sides are Equal.

Rule.—Multiply the length by the breadth.

Thus a *square*, each of whose sides is 5 inches, or feet, &c. will be 25 inches, feet, &c. in area* or content.

A Parallelogram, 18 in length and 6 in breadth, will be found 108 in area.

* *Area*, a space contained between lines.

The Rhombus and the Rhomboides, whose angles are not *right angles*, must have their breadth ascertained by erecting or letting fall a perpendicular.

To Measure any Right Angled Triangle.

Rule.—Multiply the base by half the perpendicular, or the perpendicular by half the base, i. e. multiply *one leg* forming the right angle by *half* the *other*.

To Measure any Triangle.

Rule.—Ascertain the perpendicular height and multiply the base by half the perpendicular height, or the perpendicular height by half the base—the product will be the area.

To Measure a Trapezium.†

Rule.—Divide the figure into triangles and compute each separately, and then add the sums together.

† Τραπέζιον, a small table.

To Measure a Trapezoid. *

RULE.—Add the parallel sides and multiply half their sum by the distance between them.

* Τραπεζιον. ειδος.

To Measure an Irregular Polygon.

RULE.—Resolve the figure into squares, parallelograms, triangles, &c. as may be most convenient, and measure each figure separately, their sum will be the area of the whole polygon.

As it is presumed the pupil has not made a great progress in arithmetic, the measurement of figures requiring farther calculation is reserved till a future time. It may, however, be not improper to notice that workmen in general reckon three times the diameter to be equal to the circumference of a circle, which is not strictly accurate.

The diameter of the circle may be considered in proportion to its circumference, as 7 is to 22.

If the diameter be 14, then by the Rule of Three, 7 : 22 :: 14 : 44.

If the circumference be 44, then 22 : 7 :: 44 : 14.

To Measure a Circle.

RULE.—Multiply half the circumference by half the diameter—the product will be the area.

SECTION XIV.

Stereometry on the Measuring of Solids.*

Agreeably to the plan proposed, the following directions are given to find the superficies and the solid content of a few of the most familiar figures.

* Στερεος, solid. μετρεω, to measure.

A CUBE.

To Find the Superficies.

Rule.—Multiply the area of one side by 6.

To Find the Solid Content.

Rule.—Multiply the area of one side by the length of one side.

A PARALLELOPIPEDON, A PRISM, OR A CYLINDER.

To Find the Superficies.

Rule.—Add the area of the four sides and the area of the two ends together.

To Find the Solid Content.

Rule.—Multiply the area of one end by the length.

A CONE OR A PYRAMID.

To Find the Superficies.

Rule.—Multiply half the perimeter* of the base by the length of the side.

If the superficies of the base be also required, find its area and add it to the above.

* περι, about. μετρον, measure.

To Find the Solid Content.

Rule.—Multiply the area of the base by *one third* of the perpendicular height.

A SPHERE.

To Find the Superficies of a Sphere.

Rule.—Multiply the diameter of the sphere by its circumference.

To Find the Solidity.

Rule.—Multiply the surface by one sixth of the diameter.

The Figures requisite for Forming the Five Solid Bodies, commonly called the Platonic Bodies.

There are only five sorts of regular solids.

A Tetraëdon.†—Fig. 88.

Consists of four equilateral triangles, which when folded according to the lines will form a pyramid.

† Τετρα, four. Εδρα, a base.

An Hexaëdron.—Fig. 89.

Consists of six equal squares, which when folded up will form an hexaëdron or cube.

An Octaëdron.—Fig. 90.

Consists of eight equal triangles.

A Dodecaëdron.—Fig. 91.

Consists of twelve pentagons.

An Icosaëdron.—Fig. 92.

Consists of twenty triangles.

These figures described on pasteboard, &c. and partially cut along the lines, may be folded till the sides meet, which being pasted or glued together, will give the form of the five Solid Bodies whose sides are equal, and whose surfaces are similar and equal.

SECTION XV.

Altimetry and Longimetry,† or the Mensuration of Heights, Depths, and Distances.*

To Ascertain any Short Inaccessible Distance, as the Breadth of a River by the Verge of the Hat.—Fig. 93.

Draw down the verge till its edge appears to touch the spot whose distance is to be measured;

* *Altus*, high. μετρεω, measure.

† *Longus*, long.

place one hand under the chin to keep the head steady, then turn towards some level ground, and observe a point in that line in which the verge of the hat limits the view—the distance from the observer to that point being measured will give the answer.

The inaccuracy of this method is obvious from the almost impossibility of keeping the head so steady as neither to enlarge nor to diminish the angle of vision in the act of turning.

To Measure the Height of an Accessible Object by the Reflection from a Looking-glass on a Bason of Water.—Fig. 94.

Let a mirror or bason of water, with two lines across to determine the centre, be placed level with the base of the object, and let the observer move back till the top of the object appears at the centre of the reflecting surface.

The height of the object will be in the same proportion to the distance of its base from the point of reflection that the height of the eye is to the distance of the observer from the point of reflection.

Rule.—Multiply the height of the observer's eye by the distance between the mirror and the base of the object, and divide by the distance between the mirror and the observer.

Thus—The height of the observer's eye .... 5 ft.
The distance of the observer from the mirror .... } 6 ft.
Distance between the mirror and the base of the object .... } 13 ft.

6 : 5 :: 13

$$\begin{array}{r} 5 \quad \text{ft.} \quad \text{in.} \\ 6\,\underline{)65(}\ 10 \quad 10 \end{array}$$

To Measure the Height of an Accessible Object, as a Tree, Obelisk, or Tower by the Length of its Shadow, when either the Sun or the Moon shine so as to produce a Shadow.—Fig. 95.

Place a staff perpendicularly in the same plane with the tree—measure the height of the staff—the length of its shadow, and of the shadow of the object.

The shadows of all objects in the same plane being in the same proportion to their respective objects, if the staff be 3 feet in height and its shadow 2 feet in length, a shadow 20 feet in length will be produced by a *tree* 30 feet high.

Rule.—Multiply the shadow of the tree, obelisk, or tower by the length of the staff, and divide the product by the shadow of the staff.

Thus—Shadow of the Tree .... 80 ft.
Height of the Staff .... 3 ft.
Shadow of the Staff .... 5 ft.

5 : 3 :: 80
3

5) 240 (

Answ.— 48 ft.

To Measure the Height of an Accessible Object by means of a Staff independently of its Shadow.—Fig. 96.

Fix in the ground a staff whose top will be higher than the eye of the observer—select a station whence the top of the staff and the top of the object may be viewed in a direct line.

RULE.—Multiply the height of the staff by the distance of the staff from the object and divide the product by the distance of the observer from the staff.

Thus—The height of the staff .... 5 ft.
Distance of the staff from the object 60 ft.
Distance of observer from the staff . . 6 ft.

To take the Height of an Accessible Object by the Quadrant only.

Look through the sights to the top of the object, and advance towards it or recede from it, till the plumb line cuts 45°, then the *distance* of the observer, from the object will be *exactly equal* to the *height* of the object.

If the line cut $22\frac{1}{2}°$, the *distance* of the observer will be *twice* the height of the object.

If the line cut $72\frac{1}{2}°$, the distance of the observer will be half the height of the object.

To Measure the Distance of a Thunder Cloud during the Storm.

Suspend a ball by a wire or thread 39 inches and 2 tenths of an inch in length, which will form a pendulum vibrating seconds—at the instant the flash of lightning is perceived, set the ball in motion and notice the number of vibrations before the thunder is heard; and because the velocity of sound is 1142 feet in a second, multiply the number of vibrations by 1142, and the product will give the distance of the cloud.

Thus—If 11 seconds elapsed between seeing the flash of lightning and hearing the thunder.

1142
11

Feet in a mile 5280) 12562 (2 miles 667 yds. 1 ft. *Ans.*
10560

Feet in a yard 3) 2002 (
667—1

The length of a half-second pendulum is 9 inches and 3 tenths.

The number of vibrations counted between the flash and the report of a gun will show the distance of a ship, &c.

To Ascertain the Velocity of the Wind influencing a Cloud.

On any level space notice an extremity of the shadow of a cloud and observe the number of seconds that elapse during its passage to another point at a measured distance.

The number of seconds will be to one hour as the distance of the two places to the fourth number; or

Divide the distance by the number of seconds, and it will give the velocity of the Wind per second—multiply by 60 and it will give the velocity of the Wind per minute—multiply by 60 again and it will give the velocity per hour.

In like manner the velocity of Water may be ascertained in a uniform current.

To Ascertain Heights and Depths by the Velocity of Falling Bodies.*

Let fall a stone or bullet from the top of the height or depth to be measured, and notice the number of seconds that elapse during its fall; the velocity of its descent will be continually increasing according to the numbers 1, 3, 5, 7, 9, 11, &c.

* *Velocitas*, swiftness.

A body will fall 16 feet in the 1st second.

Three times 16, i. e. 48 feet in the 2d second, which added to the former, will be 64 feet in two seconds.

Five times 16, i. e. 80 feet in the 3d second, which added to 64 feet, will be 144 feet, the space passed through in three seconds.

Seven times 16, 112 feet in the 4th second, which added to 144 feet, will be 256 feet, the space passed over in four seconds.

Nine times 16, i. e. 144 feet in the 5th second, which added to 256 feet, will be 400 feet, the space passed over in five seconds.

RULE.—Multiply the time of descent by its own number and multiply the product by 16.

REQUIRED.—How far will a falling body descend in *five* seconds.

$$
\begin{array}{rrl}
 & 5 & \\
 & 5 & \\
\hline
 & 25 & \text{the square of the time.} \\
 & 16 & \\
\hline
3\,) & 400 & \text{feet.} \\
\hline
\textit{Answ.}\text{—} & 133 & \text{yards 1 foot.}
\end{array}
$$

To Ascertain the Altitude of an Object, as a Tower, Steeple, &c. by the Angle of Elevation at one station.—Fig. 97.

At a measured distance, suppose 100 feet, in a right line from the object, take with a quadrant the angle of the elevation of the top of the object—for instance 47°.

Draw A B 100—erect a perpendicular at B—lay down angle A 47°, and continue the line till it intersects the perpendicular at C—then B C will be the height of the object.

Add the height of the observer's eye 5 feet

Answ.—107¼.

To Ascertain the Height of an Accessible or Inaccessible Object by the Angles of Elevation at two stations, a measured distance from each other.—Fig. 98.

If the object be fixed as a *tower*, an *obelisk*, &c. one person may make both observations; but if the object be in motion, as a *kite*, a *balloon*, *cloud*, &c. two persons in a right line at a measured distance from each other must take their observations at the same instant.

Required, the perpendicular height of a Balloon.

Angle A 35°, angle B 55°, and the distance between A and B 300 feet.

Draw A D and set off A B 300—lay down angle A 35°, angle B 55°, continuing the lines till they intersect each other—from the point of intersection let fall a perpendicular, then C D will be the height required.

Answ.—412.

To Ascertain the Distance of an Accessible or Inaccessible Object by the Angle of Depression.—Fig. 99.

Required the distance of a ship, 18° being the

angle of depression when taken from the top of a tower 145 feet in height.

Draw a line A B to represent the base, erect the perpendicular A C 145 feet—then draw C D parallel to A B, and draw C B, forming an angle of 18° with the line C D, and C B will be the distance from the top of the tower to the hull of the vessel.

Answ.—446.

In like manner the distance from the mast of a ship to an object on shore or from the mast of one vessel to the hull of another may be ascertained.

To Ascertain the Height of one Object on the Top of another, as of a Spire above the Tower, or of a Castle on a Hill or Rock.

If accessible, on a level with the base of the lower object, at a measured distance take the angle of elevation of the top of the spire or castle, and then find the height of the lower object and subtract the latter from the former.

If inaccessible, take the height of each object by angles at two stations and subtract as before.

SECTION XVI.

Miscellanea Relative to Geography,† &c.*

INCIDENCE‡ & REFLECTION,§—Whatever angle is formed with a surface by the line described by a body striking that surface, a similar angle will be formed by the substance in its rebound.

Thus a substance striking in a direction forming *right angles* with the surface A B will rebound at *right angles*—if in any direction more oblique, as E C and F C, it will rebound with a similar angle beyond the point of contact.—*Fig.* 100.

Hence will be understood that whatever is the *angle* of *incidence* formed by a ray of light, the *angle* of *reflection* will be the same.

This may be evidenced by any one viewing objects either *directly* or *obliquely* reflected from a mirror.

SOUND is reflected in a similar manner.

* Μισγω, *Misceo,* to mix various things together.

† Γη, the Earth. γραφω, to describe.

‡ *Incido,* to fall upon.

§ *Reflecto,* to turn back.

REFRACTION.‖—Light is not only reflected perpendicularly or obliquely, but it also undergoes what

‖ *Refringo,* to break.

is termed a refraction on passing out of one *medium* * into another of a different degree of density; † as from the rarer fluid in the higher regions into the common atmospheric‡ air, and from the air around us into glass or water, &c.

Suppose A B to be a body of glass, water, or oil, a ray of light, as C d, passing through one medium and entering another in a perpendicular direction will proceed perpendicularly; but if it enter the second medium obliquely, as r d, the direction of its course will be changed in the denser medium becoming more inclined towards the perpendicular C F.—*Fig*. 101.

When the ray passes from a denser medium, as *glass*, &c. into one more rare, as *air*, &c. the refraction causes the ray to proceed in a direction farther from the perpendicular.

Refraction may be exemplified by placing a shilling at the bottom of a bason, and preventing its slipping by means of putty or wax, &c. If one person take a station which admits of seeing the inside of the bason without seeing the shilling—and another person pour water into the bason, the reflected ray from the shilling which before struck against the side

* *Medium.*

† Δασυς, *densus*, compact, thick.

‡ Ατμος, vapour. Σφαιρα, a sphere.

of the bason becomes refracted and meets the eye of the spectator.—*Fig.* 102.

THE SENSIBLE* HORIZON.†—The boundary of the view of a spectator on the surface of the earth or water where the eye can have a field of vision uninterrupted till the sky and the land or water appear to unite in a larger cicle.—*Fig.* 103.

* *Sentio*, to perceive.

† Οριζω, to bound or terminate.

The RATIONAL‡ HORIZON—is the view which a spectator might be conceived to have if stationed at the centre of the earth.

‡ *Ratio*, reason.

Great as the difference appears with respect to the earth, it is inconsiderable as it respects the heavens, because the fixt stars are so remote that the semi-diameter of the earth about 4000 miles can make no material difference in their appearance.

It is evident that a planet at b would be in the horizon of a spectator at the centre of the earth—at B in the horizon to person on the surface.

The quantity of the angle B C b is called the horizontal Parallax,§ i. e. the *arc* intercepted between the true and the apparent place of any of the heavenly bodies.

§ Παραλλαξις, difference.

TWILIGHT* is a varying effect produced by the *reflection* and *refraction* of light, and gradually increases or decreases in proportion to the Sun's distance below the horizon, and ceases to be perceptible when that distance is more than 18°.

* Probably from 'twixt and light, which accords with the French, *entre Chien et Loup*.

To take the Altitude of the Sun by a Quadrant.

If the instrument be either Gunter's or the more homely quadrant mentioned p. 36—unless it be provided with a dark glass—let the quadrant be held with its face towards the observer, so that the Sun's beams may pass through both sights—then the plumb line will cut the degree expressing the angle of altitude.

The Sun, when near the horizon, appears higher than its real situation, in consequence of its rays being refracted in the atmosphere.

The degree noted by the quadrant will not be strictly accurate on account of the *refraction* which takes place in the atmosphere. The difference between the real and apparent altitude of the Sun, or any of the heavenly bodies, is greatest when they are near the horizon; in consequence of this refraction the Sun is visible a short time before it rises and after it sets.

To Draw a Figure of a Globe with Straight Lines, elevated for the Latitude of London.*—Fig. 104.

With an extent of 60 from the line of chords, describe a circle—draw two diameters at right angles, H O the horizon, Z N the zenith † and the nadir. With $51\frac{1}{2}°$ taken from the line of chords, place one foot of the compasses on O and intersect the circle between O & Z—from that point of intersection draw a diameter N P, S P to represent the axis of the world, the extremities of which are the North and the South poles. Draw a diameter at right angles with the axis to represent the equator, and at $23\frac{1}{2}°$ from the pole—draw lines representing the arctic and antarctic circles, and at $23\frac{1}{2}$ on each side the equator draw on the North side the tropic of Cancer or summer solstice, and on the South side the tropic of Capricorn or the winter solstice.

Take with the compasses the extent from O to the pole, and the same extent will reach from the equator to the latitude of the place.

* Latitude and Longitude are terms used in Geography. Πλατυς, *latus*, broad, *latitudo*.
Latitude is the distance of any place from the Equator in either a Northern or Southern direction.
Ογκος, λογχος, *longus*, long, *longitudo*.
Longitude, the distance of any place in an Eastern or Western direction from any point fixed on.

† Zenith and Nadir are two Arabic terms adopted in all modern languages. Zenith, the point over head—Nadir, the point opposite to Zenith.

In like manner in a figure constructed for any latitude the elevation of the pole at that place will be similar to the latitude.

To Find the Latitude of any Place by the Meridian Altitude.*—Fig. 105.

Draw H O to represent the horizon—erect a perpendicular at the centre C, and with a radius of 60 from the line of chords describe the semi-circle H Z O for the meridian.

Having found the meridian altitude at the summer solstice† to be 62°—set off 62 from H to S. The declination of the sun at that time being $23\frac{1}{2}$°, set off S E and the arc H E will be the altitude of the equator, i. e. the complement (or as abbreviated, co-latitude,) being $38\frac{1}{2}$, the remainder of the quadrant $51\frac{1}{2}$ will be the latitude of the place.

In like manner proceed with the meridian altitude at any other time.

In the summer half year set off the declination above, and in the winter set it off below the meridian altitude.

* *Meridies*, noon-day.

† *Sol*, the Sun. *Sto*, to stand, because the Sun appears to stand for a time at the solstices.

A Table of the Length in Geographical Miles for each Degree of Longitude according to the Degree of Latitude.

0	60.00	31	51.43	61	29.09
1	59.99	32	50.88	62	28.17
2	59.96	33	50.32	63	27.24
3	59.92	34	49.74	64	26.30
4	59.85	35	49.15	65	25.36
5	59.77	36	48.54	66	24.41
6	59.67	37	47.92	67	23.44
7	59.56	38	47.28	68	22.48
8	59.42	39	46.63	69	21.50
9	59.26	40	45.96	70	20.52
10	59.09	41	45.28	71	19.53
11	58.90	42	44.59	72	18.54
12	58.69	43	43.38	73	17.54
13	58.46	44	43.16	74	16.53
14	58.22	45	42.43	75	15.53
15	57.95	46	41.68	76	14.52
16	57.67	47	40.92	77	13.50
17	57.38	48	40.15	78	12.47
18	57.06	49	39.36	79	11.45
19	56.73	50	38.57	80	10.42
20	56.38	51	37.76	81	9.38
21	56.02	52	36.94	82	8.34
22	55.63	53	36.11	83	7.31
23	55.23	54	35.27	84	6.27
24	54.81	55	34.41	85	5.23
25	54.38	56	33.55	86	4.18
26	53.93	57	32.68	87	3.14
27	53.46	58	31.79	88	2.09
28	52.97	59	30.90	89	1.04
29	52.47	60	30.00	90	0.00
30	51.96				

To Find the Number of Miles contained in a Degree of Longitude in any given Latitude.

Draw the line A B, fig. 106, and divide it into 60 geographical or 70 English miles. On A with the extent A B describe an arc, and from B set off the given latitude C (suppose $51\frac{1}{2}°$)—let fall a perpendicular to D, and A D will be the measure of a degree of longitude in that latitude.

To Draw a Right Lined Map of a Part of the Earth's Surface.—Fig. 107.

Suppose it were required to delineate that part of the world which is contained between 54° and 59° North latitude, and between 1° and 7° West longitude.

Draw a line to represent the lower boundary of the map 54° latitude. On the middle of the line erect a perpendicular and divide it, according to the given number 5 of the degrees of latitude, by lines parallel to the base line.

Either select a scale equal to the distance of the parallels, or draw one and divide it into six equal parts containing 10 each.

On each side the perpendicular set off from the scale distances corresponding to the numbers given in the prefixed table—thus, against 54° stands 35.27, which would have been $35\frac{1}{4}$ had the decimal been 25.

Therefore on the lower line, i. e. the parallel of 54°,

set off the extent $35\frac{1}{4}$° three times on each side the perpendicular.

Seek in the table 59°, it appears 30.90, which may be considered 31°—that extent on the scale is to be set off on the uppermost line three times on each side the perpendicular, i. e. the parallel of 59°—draw the meridian lines to connect the corresponding divisions and annex the numbers.

In this instance the parallels and meridians are drawn at each degree;—in maps comprising a larger portion of the earth's surface it is usual to draw them at every fifth or every tenth degree.

To Take an Enlarged or Reduced Copy of any Map, Drawing or Plan.

Divide the plan, &c. and the paper on which the new drawing is to made into an equal number of squares, and delineate in the squares of the new work the corresponding squares of the given drawing.

To Reduce a Rectilineal Figure.

Make a point near the centre of the copy and draw lines from every angle to that point—measure the angles and the lines of the copy—lay down the angles as in the copy and set off the lines according to a larger or smaller scale, as proposed.

In preparing to draw a map, the following method, as described by Mr. Bonnycastle, may be found cove-

nient for erecting perpendiculars, especially near the margin of the paper.

To Raise a Perpendicular from any point B in a given line A. B.—Fig. 108.

1. From any scale of equal parts take a distance equal to 3 divisions, and set it from B to m.

2. And from the points B and m, with the distances 4 and 5, taken from the same scale, describe arcs cutting each other in n.

3. Through the points n and B draw the line B C, and it will be the perpendicular required.

The object of the preceding pages has not been to interfere with the subjects of Geography or the construction of Maps; the single instance of a Right Lined Projection is intended to exercise the Pupils in graduating, &c.

The plan usually adopted to impress the figures on the mind, is for the Pupils to draw them, of any size, on cards; and the mode of examination is to require a verbal explanation of the figures.

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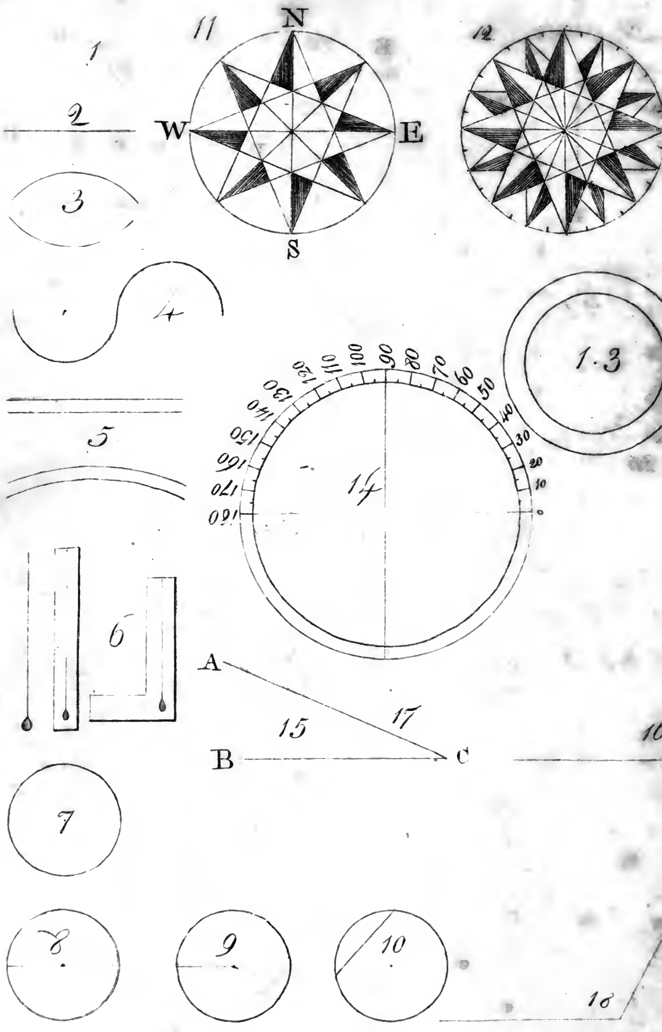
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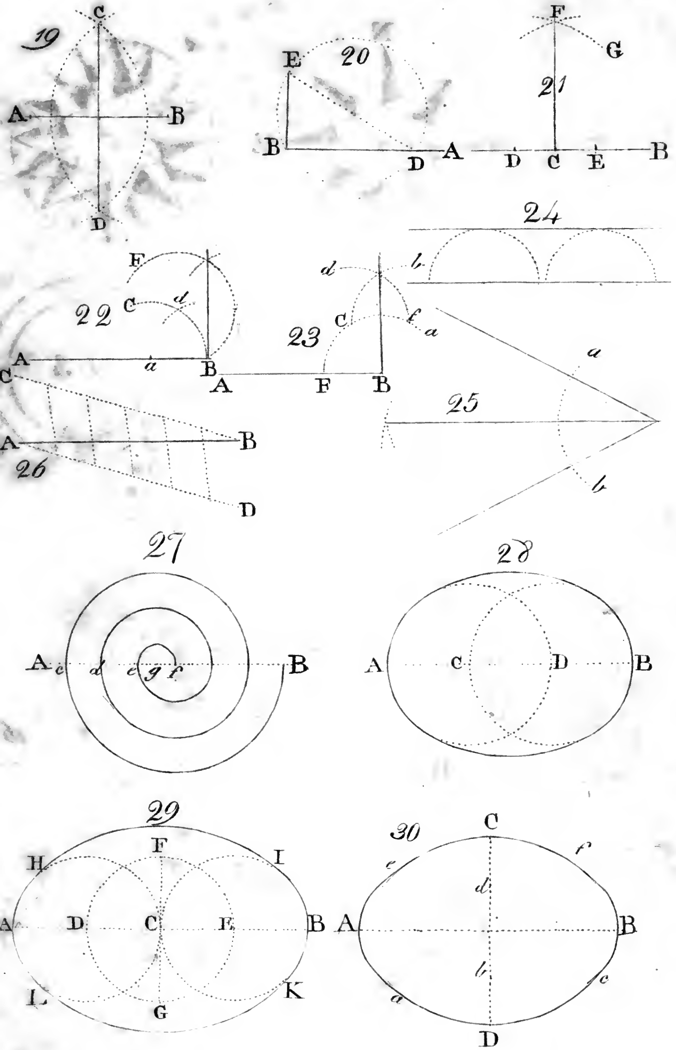
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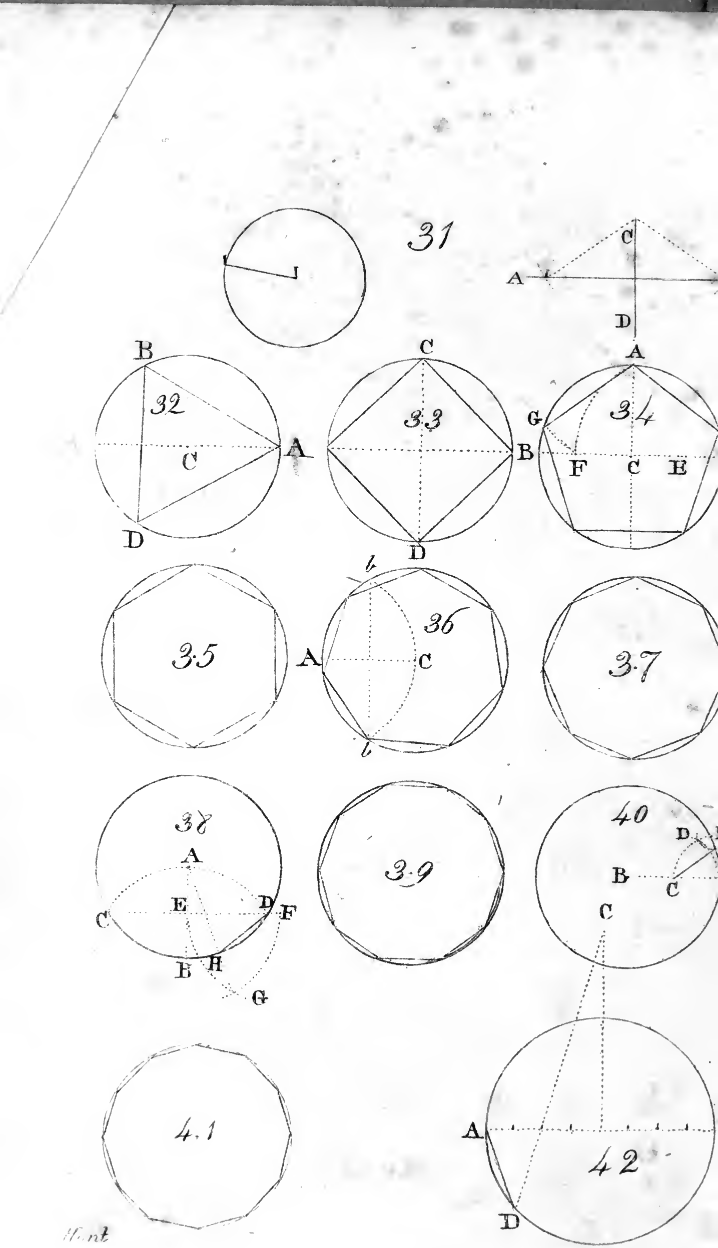
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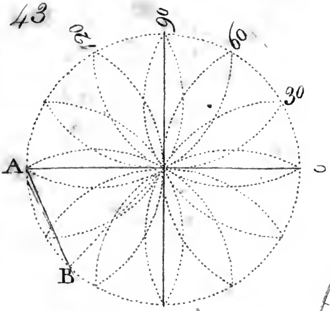
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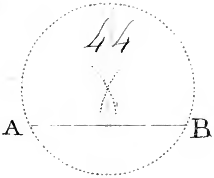
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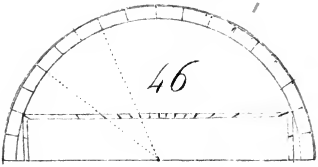
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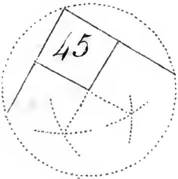
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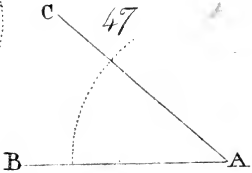
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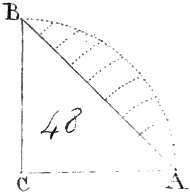
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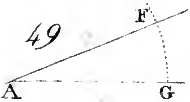
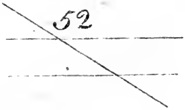

49
F
A
G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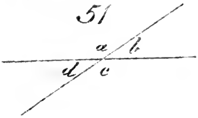
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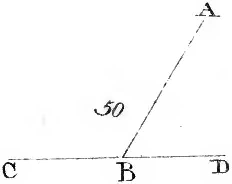
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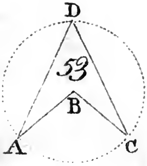
B
D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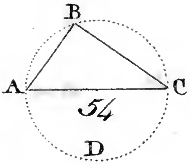
A
C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C
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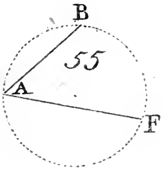
D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A
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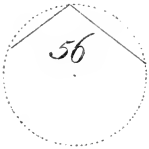
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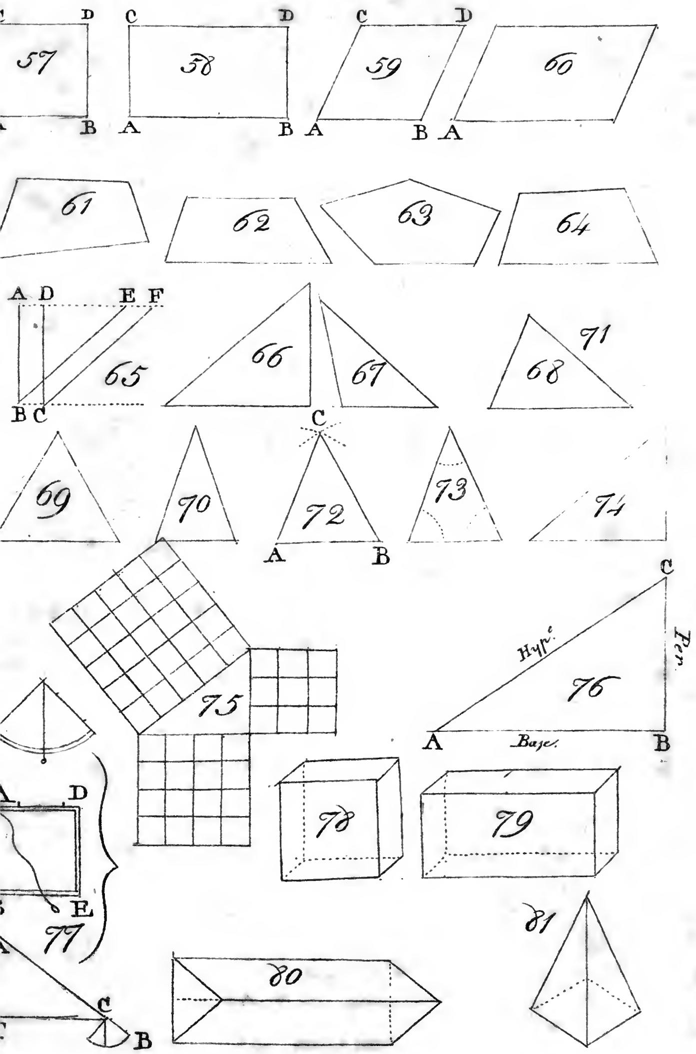
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A B C D E F
Hyp.
Per.
Base.